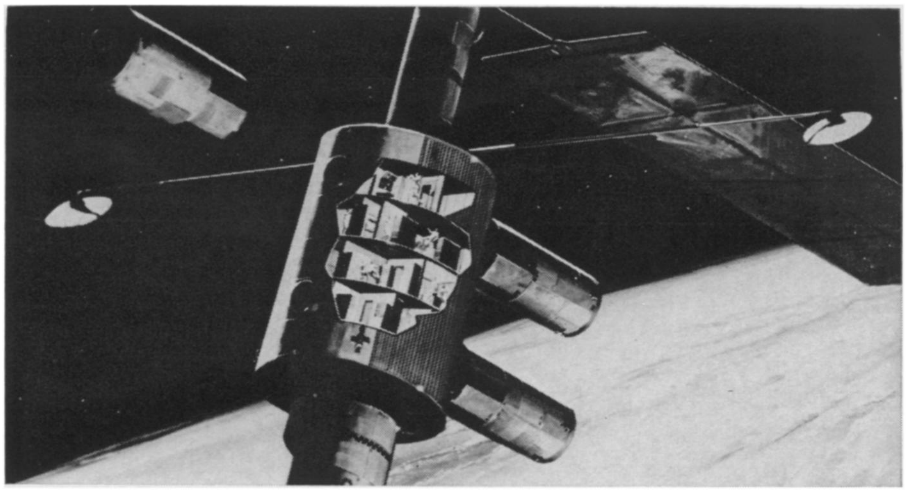

NASA

A modular space station could be operational by the end of the decade.

Options in space

NASA needs missions to follow Apollo

Millions watched as the lunar module Eagle with Astronauts Neil A. Armstrong and Edwin E. Aldrin touched down at Tranquility Base a year ago this week. Many experienced a sense of exultation at an awesome goal accomplished and man's horizon extended to an unprecedented degree.

In the year that has followed, however, the winds have been diverse; the nation has turned inward to the festering sores of earth's society and demanded that they be healed. But no identifiable goal with economic and political appeal has been forthcoming and no clear cut directions have emerged.

In the National Aeronautics and Space Administration a year after the moon, with a universe of potential targets but no political mandate for any one of them, much of the same lack of focus is apparent.

The agency must select a course among the varied alternatives while struggling to remain viable as an organization. Drifting out of the mainstream of national efforts it has less than one-third of its peak work force and only a little more than half of its peak budget (SN: 7/11, p. 33). And the reassessment of goals now going on at the top level of management has left, in many cases, space crews restless, lower echelon managers groping for direction and the various NASA centers competing for a piece of the action —whatever it turns out to be.

The calendar for the 1970's for unmanned flights seems set, though not all of the programs are funded. These include two Mars orbiters to be launched in 1971 ($144.8 million); one flight past Venus and Mercury in 1973 ($110.9 million); two Pioneers, F and G, through the asteroid belt to Jupiter in 1972 and 1973 ($116.9 million); two Mars soft landers to be launched in 1975 ($878.9 million), and the Grand Tours to the outer planets in 1977 and 1979 (up to $1 billion).

But the unselected options lie in the area of manned space flight: the development of the program of the 1970's—that of the space station and shuttle; how best to use remaining Apollo hardware, and how to bridge the gap between now and planetary missions almost two decades hence.

Basic to the option-selecting process are several essentials: the development of a program flexible enough to respond to rapidly shifting political winds; the development of economical and reusable hardware, and a change in philosophy. The space station and shuttle should supply a flexible and economical program. The change in philosophy is more subtle.

Whereas the astronauts have been used to a mission concept of flight which lasted two weeks or less, with years of training climaxed in a heraldic return, the remaining 42 active post-Apollo astronauts must adjust to long lead times and years of training, and for flights that will last for a month and longer. And whereas the Apollo program was dramatic in its other-planet appeal, the space stations and workshops will be to some extent a return to something that is not new—earth-orbital flights.

And man's role in space, whether in earth-orbital or planetary flights, may well change to that of a complementary subsystem, doing tasks that cannot be accomplished by automated systems. This may mean that such extravehicular jobs as the crewmen will perform in the first workshop, Skylab, tending the Apollo Telescope Mount, for example, may in the future be done by robots, and even the drama of the spacewalk might disappear.

In addition to these transitions NASA is faced with three major decisions: what to do with the remaining seven Saturn 5's, and how soon and at what pace to develop the modular space stations and shuttle.

The Saturn 5's had been originally

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Paine: Studying the options.

earmarked for Apollos 14-20. But Apollo 20 fell to Skylab A. Before the abort of Apollo 13, the schedule called for two flights in 1970 (13 and 14), two in 1971 (15 and 16) and Apollo 17 in the first part of 1972, with Skylab flying during the last quarter. Apollos 18 and 19 were slated for 1974.

The abort of Apollo 13 caused the delay of Apollo 14 to Jan. 31, 1971 at the earliest. Should the space agency choose to use Apollo 15 for Skylab B, there could still be three moon explorations before the workshop flight in 1972, with Apollos 14, 16 and 17.

Opponents to continued lunar flights argue that in the face of the money-squeeze there will be diminishing returns in terms of utility and information. The first landing returned the most in terms of data, they argue; subsequent landings, while they may increase the confidence in the data-determination of the first landings, offer less. Thus Apollos 18 and 19 face strong competition from other data-gathering mission concepts. On the other hand, Apollo proponents point out that both moon flights have raised almost more questions about the moon than they have answered; they argue that future flights should hold an equal number of scientific surprises.

One of Apollo's rivals, funded and approved for 1972, is the earth-orbital workshop, Skylab A, delayed since 1968 when it was called the Apollo Applications Program. This orbiting lab has the potential to demonstrate the usefulness of space to earth, and NASA is basing high hopes on the payoff. Experiments include 16 medical, 8 engineering and 17 scientific (including biological, astronomical and solar) and 9 technological programs.

Skylab B, to fly in late 1973 or 1974, is a possibility that has support, particularly from scientists who have been left out of Skylab A.

Regardless of the decisions concerning the Apollo-Skylab schedule, NASA is still faced with a manned flight gap from 1974 to 1978. The possible bridges across that gap include an intermediary space station using Apollo instead of space-station module hardware, the development of a prototype shuttle or an all out effort on the space station.

One way to maintain the operational level of manned flight is that of the intermediate space station, designed to house from 6 to 12 men. One of these could be launched in 1975-76 and another in 1977-78. Ideally, the space station could serve a purpose other than its scientific role: international cooperation. International involvement in the space probe is an avowed aim of NASA's administration and because of the increasing space costs, it has been gaining Congressional support.

Although the Apollo hardware space station would not be of the design and sophistication of the space station/base planned for the latter part of this decade, it could supply necessary data for such a program as well as filling a debilitating gap.

Another alternative is the flight of a prototype shuttle prior to the shuttle now planned for 1977-78. The two-step shuttle program has been gaining support from among scientists who like the idea of flight for nonastronauts.

The shuttle ultimately would allow the scientists to go up in shirt sleeves, with equipment for experiments ranging from a few days to weeks, and return to earth laboratories to reduce their data.

Considering these options, NASA Administrator Thomas O. Paine is expected to make some major decisions within the next two months as budget preparations for fiscal 1972 start.

"We would be most reluctant to give up any of the future moon flights," says Dr. Paine. "On the other hand, we are also determined to push forward in the areas of the space station and shuttle." □

MOLECULAR BIOLOGY

A two way street for genetics

Deoxyribonucleic acid, as every good biologist knows, is the master genetic chemical, containing as it does the blueprints for the design of all living substances. DNA, for example, transfers its architectural instructions to RNA (ribonucleic acid) which dutifully carries them to ribosomes, cellular factories where proteins are assembled according to the dictates set down by DNA. According to this now well established dogma, RNA is an essential link in the transfer of genetic information but is an Indian, not a chief.

Dogmas in science have a habit of undergoing change. The central thesis of molecular biology, that the genetic code passes from DNA to RNA along a one-way street, is no exception. New data, produced from three separate laboratories during the last few weeks, are forcing change: Information is transmitted from DNA to RNA most of the time, but sometimes, as in the case of tumor-causing RNA viruses, it goes in the opposite direction. RNA can code for DNA. The genetic code travels a two-way street.

The unorthodox idea that DNA can be produced from an RNA template was first proposed in 1964 by Dr. Howard Temin of the University of Wisconsin at Madison. Since then, he recounts, numerous papers have been published demonstrating that his hypothesis could not be true. But from experiments with the Rous sarcoma virus which causes tumors in birds, Dr. Temin now has evidence substantiating that this virus, consisting only of a core of RNA encased in a protein coat, can make DNA once it infects a cell. Further, this RNA-made DNA is passed to daughter cells, carrying with it instructions for the production of more cancerous cells.

The RNA-to-DNA inversion, Dr. Temin suggests, may explain the mechanism by which viruses known to induce cancer in animals work. With Dr. Satoshi Mizutani, he reported his findings in the June 27 NATURE. In the same issue, Dr. David Baltimore of the Massachusetts Institute of Technology reported verification of Dr. Temin's theory, now being referred to as Teminism in scientific circles, from experiments with another carcinogenic virus, the Rauscher leukemia virus, which induces tumors in mice.

There are many RNA viruses, including those that cause colds, flu and measles, that infect a cell and use its genetic machinery to produce more RNA viruses, which in turn spread to and infect other cells. These are not suspected of Teminism; where RNA tumors viruses differ is in that they somehow manage to induce a permanent infection, transmitting their carcinogenic genetic message into the genes of infected cells, not destroying them, but changing them so that they pass this deleterious information on in cell division. From observations of the biological behavior of cells infected by the Rous sarcoma virus, Dr. Temin reasoned that the RNA viral core must be able to produce DNA that is an image of itself. This, he suggests, is accomplished with the aid of unique enzymes, ones that could synthesize DNA from an RNA template.

Drs. Temin and Mizutani and Dr. Baltimore have evidence that such enzymes exist. Called RNA-dependent DNA polymerases, the enzymes, not yet isolated, appear to catalyze the synthesis of DNA but require an RNA template from which to work. Biochemical studies have indicated the presence in the virion or genetic core of both Rauscher and Rous viruses of polymerases specific for each of them. These polymerases apparently are not present in normal cells.

Impressed by the results of the experiments performed by the Wisconsin and Massachusetts scientists, Dr. Sol Spiegelman of Columbia University's Institute for Cancer Research attempted to repeat them. Originally as skeptical of Dr. Temin's hypothesis as other molecular biologists, Dr. Spiegelman has developed the ideas strongest confirmation so far. Testing a dozen RNA viruses for their ability to code for DNA, he finds that eight can and four cannot. The eight which produce DNA cause cancer in animals; the other four do not.

From the combined results of the work of these four scientists there emerges a new explanation of the mechanism of viral carcinogenesis, linking it directly to the phenomenon of the reverse transfer of genetic information. Additional work needs to be done to refine understanding of the specific polymerases involved in this process, but as it is accomplished—it is likely that numerous laboratories will begin working on Teminism—several results are possible:

- Detailed examination of the RNA-to-DNA pathway by means of a specific enzyme phenomenon could produce a way of predicting the carcinogenic potential of viruses;
- The work may offer clues to methods of inhibiting them.

On a broader scale, Dr. Temin suggests that his theory may lead to insights into the mechanism of information transfer in other biological systems, including the immune system and the process of cell differentiation. □